Meta-Analysis

Goals

- Same as traditional narrative review but more quantitative
- Do Narrative review first
- Integrative Review
  - Uses statistical analyses to combine results of previous studies
  - Less likely to allow researcher bias to enter into conclusions
  - Can compute mean effect sizes for IV
  - Can compute significance of mean effect size, and of difference between mean effect sizes in different conditions of a moderator
  - For testing mediational hypotheses – (Shadish, 1996)

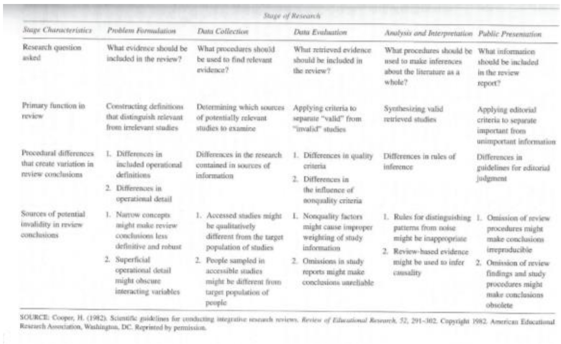
Cooper & Rosenthal (1980)

- Professors and Graduate students reviewed 7 studies: Sex and persistence at tasks
- A) traditional narrative review
- B) Statistical review
  - Perceived larger difference between males and females, who were more persistent

Brief History

- 1904 – 1st application
- Pearson – 11 studies of vaccine against typhoid
  - Averaged measures of treatment's effect across two groups of studies
  - On basis of average correlations, concluded that all other vaccines were more effective
- 1932 – Fisher
  - *Statistical Methods for Research Workers*
    - Test for combining p values from independent tests of same hypothesis
- Techniques not widely implemented until 60s
- 1976 – phrase coined by Gene Glass

Cooper (1982) five-stage model



	Stage of Research				
Stage Characteristics	*Problem Formulation*	*Data Collection*	*Data Evaluation*	*Analysis and Interpretation*	*Public Presentation*
Research question asked	What evidence should be included in the review?	What procedures should be used to find relevant evidence?	What retrieved evidence should be included in the review?	What procedures should be used to make inferences about the literature as a whole?	What information should be included in the review report?
Primary function in review	Constructing definitions that distinguish relevant from irrelevant studies	Determining which sources of potentially relevant studies to examine	Applying criteria to separate "valid" from "invalid" studies	Synthesizing valid retrieved studies	Applying editorial criteria to separate important from unimportant information
Procedural differences that create variation in review conclusions	1. Differences in included operational definitions 2. Differences in operational detail	Differences in the research contained in sources of information	1. Differences in quality criteria 2. Differences in the influence of nonquality criteria	Differences in rules of inference	Differences in guidelines for editorial judgment
Sources of potential invalidity in review conclusions	1. Narrow concepts might make review conclusions less definitive and robust 2. Superficial operational detail might obscure interacting variables	1. Accessed studies might be qualitatively different from the target population of studies 2. People sampled in accessible studies might be different from target population of people	1. Nonquality factors might cause improper weighting of study information 2. Omissions in study reports might make conclusions unreliable	1. Rules for distinguishing patterns from noise might be inappropriate 2. Review-based evidence might be used to infer causality	1. Omission of review procedures might make conclusions irreproducible 2. Omission of review findings and study procedures might make conclusions obsolete

SOURCE: Cooper, H. (1982). Scientific guidelines for conducting integrative research reviews. *Review of Educational Research, 52,* 291–302. Copyright 1982. American Educational Research Association, Washington, DC. Reprinted by permission.

Cooper (1982) five-stage model

- Threats to inferential validity
- Later users of data must be as accountable for the validity of their methods as the original data gatherers
- Check Validity
  - Internal
  - Theoretical
    - Are conditions met?
  - Ecological

Mullen et al. (1991) Validity Check

- 1. Exclude studies highly flawed in internal or construct validity
  - E.g., use of measure later deemed invalid
  - Construct design flaw analysis
    - Matrix where rows = studies and columns = validity threats
- 2. Establish explicit set of criteria for judging validity
  - E.g., random assignment?
- 3. Classify studies as to their degree of validity and factor into analysis

Procedures

- **Literature Search**
  - Published AND unpublished sources
    - Why?
  - Must include estimates of effect size
    - Problems?
- 10-15 studies minimum
  - 10-15 studies per condition of moderator
- Level of analysis
  - "Mixing apples and oranges" – e.g., combine effect sizes across different types of therapy
  - Mixing across DVs even more problematic

Operationally Defining Study Outcomes

- 1. support/not support hypothesis
  - Vote-counting
- 2. multiple outcome categories
  1. sig. and supported H1
  2. not sig. but supported H1
  3. IV had no effect
  4. not sig and contradicted H1
  5. sig and contradicted H1
- 3. effect size
  - *d* and/or *r*

Example

- Remedial education and self-esteem
  - H0 = adults receiving and not receiving education do not differ in SE
  - Extract from Methods and Results, information on each of the relevant study characteristics
    - E.g., age, measures, sex etc.
    - Reliability from a sample of those studies

Procedures

- Vote Counting
  - Divide reports into piles:
    - Statistically significant, no differences, null hypothesis
  - Side with larger pile

  - Problems with this method?

Procedures

- Vote Counting
  - If null is true, 1/20 (5%) studies will suggest significance by chance alone
  - The “largest pile wins” strategy requires that 7/20 (34%) of the studies must be significant before that conclusion is accepted
    - (fewest # in a pile to be considered largest when 20/3)
  - But what if five studies showed significant relationship between self-esteem and remedial education?
  - Two studies can have same effect size (e.g., *r* = .25), but larger sample (N = 100) be sig. and smaller sample (N=50) NS

Procedures

- Vote Counting
  - **Susceptible to Type II errors**
  - Strategy does not weight reports differently based on sample size!
  - Effect sizes from larger samples should be given more weight
  - Also does not weight large and small mean differences differently

Procedures

- **Combining Probabilities**
  - Extract *p* associated with each test of the null hypothesis
  - Generate a single probability that relates to the likelihood of obtaining a run of studies with these results given that null is true
  - E.g., what is the combined probability of finding that education has no effect on self-esteem with 20 studies?

Procedures

- **Combining Probabilities**
  - E.g., Remedial education and self-esteem
- What should researcher conclude if:
  - combined probability was $p < .03$?
  - Combined probability was $p < .19$?

- Overcomes improper weighting problems BUT is very powerful
  - Very high likelihood of rejecting null if treatments have generated a large N of studies
- Also, tells you effect exists but not its size

Procedures

- **Effect size estimation**
- Reframe – *how much does* remedial education influence self-esteem?
- Positive values indicate that effect size is consistent with hypothesis
- Negative values indicate opposite hypothesis

Procedures

- **Effect size estimation**
  - If examining relationship between two continuous variables (e.g., GPA and self-esteem) – use Pearson's product moment correlation

Procedures

- **Effect size estimation**
- If comparing treatment to control group
- Cohen's d – standardized mean difference
  - Scale-free measure of the number of SDs between two group means
  - $$D = \frac{x_1 - x_2}{\frac{SD_1 - SD_2}{2}}$$

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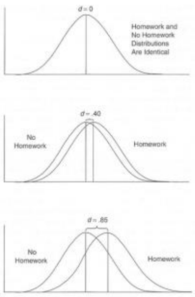


Figure 21.1 Three Hypothetical Relations Between Education and Control Groups in Self-Esteem Experiments

Procedures

- **Effect size estimation**
  - To determine how big of a difference between education and control conditions exists for all studies in the sample on average:
    - Calculate *d* for each outcome in each study
    - Weight them by sample size
    - Average all *d* indexes
    - This average effect size ignores characteristics of the studies

    - Lipsey & Wilson (2001) – SPSS and SAS code
    - Comprehensive Meta-Analysis

Influences on Effect Sizes

- Calculate average *d* indexes for subsets of studies with common characteristics
- Homogeneity analysis
  - Test whether these factors are reliably associated with different magnitudes of effect (different average *d* indexes)
  - Group studies according to potentially important characteristics and test for between-group differences
  - If significant, differences in effect size are not due to sampling error alone
  - * Results do NOT allow causal statements *

Sensitivity Analysis

- What happens if some aspect of the data or the analysis is changed?
- Funnel plot
  - Depicts sample size of studies versus estimated effect size for the group of studies
  - Should approximate shape of normal distribution
  - But publication bias will restrict range of distribution – overrepresentation at one tail

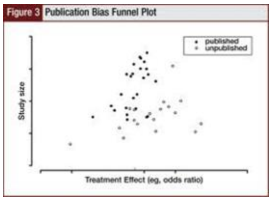
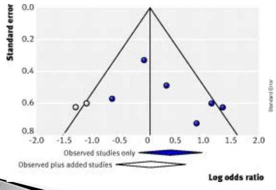
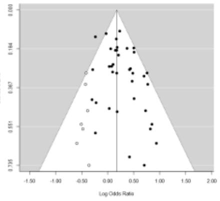


Figure 3 Publication Bias Funnel Plot

Sensitivity Analysis

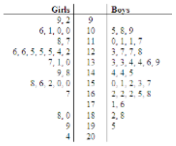
- Trim and fill method (Duval & Tweedie, 2000)
  - Through iterative process ‘fills-in” effect sizes from studies that were not represented in data set
  - Nonparametric method that estimates missing effect sizes based on normal distribution



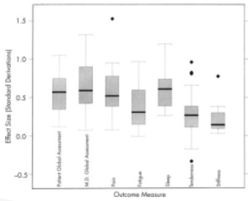


Sensitivity Analysis

- Could also prepare stem-and-leaf and box plots to examine distribution of standardized mean differences
- Remove any outlying effect size and compare result to total effect with all studies included.



Girls		Boys
9, 2	9	
6, 1, 0, 0	10	5, 8, 9
8, 7	11	0, 1, 1, 7
6, 6, 5, 5, 5, 4, 2	12	3, 7, 7, 8
7, 1, 0	13	3, 3, 4, 4, 6, 9
9, 8	14	4, 4, 5
8, 6, 2, 0, 0	15	0, 1, 2, 3, 7
7	16	2, 2, 2, 5, 8
	17	1, 6
8, 0	18	2, 8
9	19	5
4	20	



Problems

- Missing information
- Coding ambiguities
- Correlated data points
- Problems with original data collection
- Timeliness
- Be mindful that moderators are correlational

- **Useful Site: Meta Analysis Calculator**
- http://www.lyonsmorris.com/ma1/index.cfm

To Ponder

- A. What were the conceptual variables of interest?
- B. What inclusion criteria were used in selecting research for the meta-analysis?
- C. How many different measures of each of the conceptual variables were found in the literature review?
- D. What method was used to determine the average effect size?
- E. Was the statistical significance of the effect size estimate calculated? If so, how?
- F. Was the file drawer problem addressed?
- G. What problems did the authors encounter in conducting the meta-analysis? How did the authors attempt to solve these problems?
- H. What was the authors' conclusion about the relation between the variables of interest?